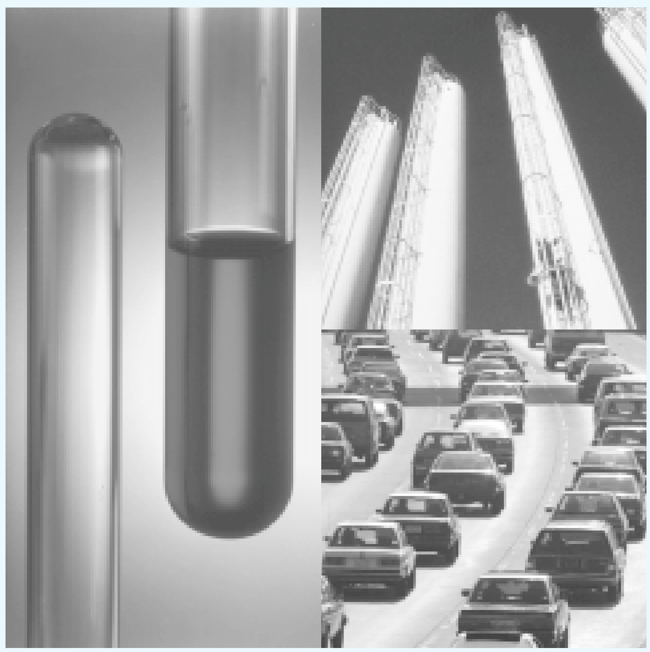
Gas PROCESSING Program



Converting Unmarketable Natural Gas Resources into Valuable Products

OIL AND GAS RD&D PROGRAMS

Trans Alaska Pipeline

In Alaska's far North Slope (ANS), there are vast natural gas resources that remain untapped because the gas is too remote from the marketplace for cost-effective, conventional pipeline transport. Even with the advent of high-efficiency liquefied natural gas (LNG), physical conversion technology, and increases in Asian LNG export demands over the last decade, the competitive economics of prospective ANS gas production remain uncertain. Similar concerns face some of our deep offshore Gulf of Mexico gas deposits. Beyond inexpensive reach of ocean-to-shore pipeline access, their economic production, and in some cases, their associated oil, remains uncertain.

Throughout many U.S. western States, there are gas reserves containing high levels of contaminants that render these reserves economically unmarketable in most cases. Finding ways to utilize such unmarketable gas resources is essential to sustaining a reliable domestic supply of gas and liquid fuels, because our Nation's most accessible and economical supplies have been depleted.

In partnership with the U.S. oil and gas industry, the Department of Energy seeks to advance technologies and processes that will enable the conversion of unmarketable gas resources into valuable oil and gas products. For instance, gas-to-liquids (GTL) technology could be used to chemically convert remote natural gas into a stable liquid form that is suitable for transport with petroleum, and even for direct use as an environmentally-desirable transportation fuel. Similarly, gas resources with high contaminant levels can be upgraded to market specifications using more efficient gas purification technologies. DOE is also seeking useable byproduct gas. In addition, advanced processes to collect and utilize methane, which is released during underground coal mining, would capture this greenhouse gas and prevent it from being vented into the atmosphere.

All of these currently unmarketable gas resources have the potential to significantly increase our domestic energy supplies, but technology development is vital to tapping that potential. Through its Gas Processing Program, DOE works with industry and the Gas Research Institute to promote gas conversion and upgrading technologies that will enhance our Nation's energy security and reduce our dependence on oil imports. These efforts also will strengthen the economic competitiveness of the U.S. oil and gas industry and create export opportunities for advanced U.S. technologies.

Gas Processing Program

Gas processing technologies convert unmarketable natural gas resources into valuable gas and oil products.

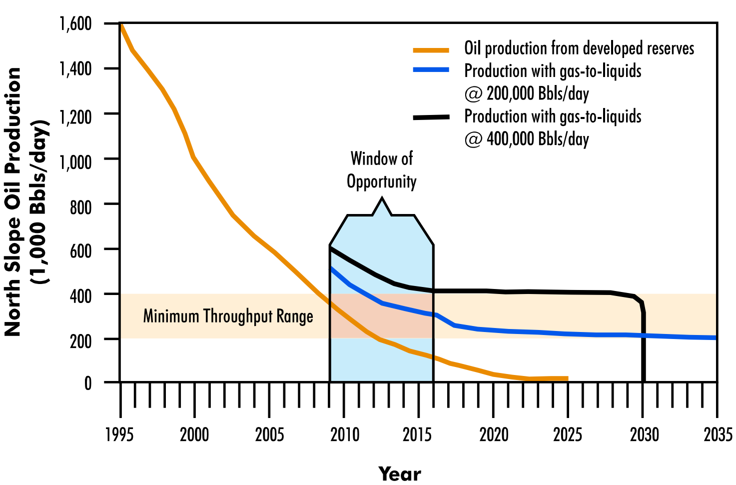
Over the past decade, DOE's Gas Processing Program has worked toward supporting our national goal to expand the development and utilization of abundant domestic natural gas resources. Use of natural gas offers environmental benefits over other conventional energy sources and helps to offset increasing oil imports.

To target unmarketable gas resources, joint government-industry RD&D efforts have focused on developing a technical base in gas upgrading and exploring processes to chemically convert gas to stable hydrocarbon liquids.

The U.S. gas processing industry currently invests $15 million to $25 million annually in these efforts. Government funding levels for the program have risen in recent years to about $9 million per year.

Recent expansion of the program is due to: new technological prospects for a potential 25 percent or more reduction in GTL conversion costs; growing market interest in the exceptional clean-burning quality of the c onversion liquid fuel products; and interest in expanding the development options for Alaska's remote gas.

Window of Opportunity for Technology Deployment to Maintain Oil Pipeline Operation and Harness U.S. Energy Potential



Government Role

The Gas Processing Program addresses two major concerns: the need for cleaner and more efficient transportation fuels; and the need for efficient use of our natural gas resource. Gas-to-liquids technologies can provide ultra-clean alternative liquid transportation fuels and additives that will contribute to reducing greenhouse gas emissions. These technologies can enable economic recovery and use of natural gas reserves in remote locations, which are not accessible to pipelines. Gas upgrading (GU) technologies can enable the economic use of low-quality natural gas, which comprises about one-third of U.S. natural gas resources and does not meet pipeline specifications.

Although advanced GTL and GU technologies exist, they are not economic in the current marketplace. State-of-the-art GTL technology requires low-cost gas and high capital investments. Advanced GTL and GU technologies have the potential to expand domestic natural gas resources, and offer a significant contribution toward meeting national environmental and alternative transportation fuel goals.

The Gas Processing Program activities are directed to the following key government roles: maximizing the public benefit of oil and gas resources; promoting effective environmental protection; and ensuring energy security. Therefore, targeted Federal support for gas processing RD&D activities is provided to foster advancement in GTL, GU, and related technologies. Federal support will help provide scientific data necessary to ensure that the most efficient and effective methods are utilized to bring these resources to market.

Tapping Remote Gas Reserves

The vast natural gas reserves in Alaska's North Slope have been without market potential because they are simply too remote from the Nation's pipelines and urban markets. One option long contemplated is construction of a gas pipeline from the North Slope to an all-weather port for LNG manufacture and export to Asia. However, competition from prospective LNG exporters geographically closer to buyers remains fierce, and the North Slope LNG economics are uncertain.

Advances in chemical conversion of natural gas suggest an added option for bringing ANS gas to market. Using chemical GTL technology, the gas could be converted into a petroleum-like liquid that is more easily transported via oil pipeline and tanker to market. Similar GTL conversion processing could be accomplished on offshore platforms or barges in the Gulf of Mexico to facilitate gas and associated oil production from wells that do not have pipeline access.

Converted gas from Alaska's North Slope could be transported through the underutilized Trans Alaska Pipeline System, which carries crude oil from the giant Prudhoe Bay field on the North Slope to Valdez for tanker shipment to markets. Production from that field is declining at a rate of about 10 to 12 percent per year. Even with additional production from newer, much smaller fields nearby, such as Alpine and Badami, pipeline flow will eventually fall below the minimum volume needed for viable pipeline operation.

Use of this existing pipeline for transport of converted gas would not only reduce the costs of producing and marketing North Slope gas, it would also ensure that as much as 200,000 barrels per day of the last remaining North Slope crude oil will not be "shut-in" due to insufficient pipeline utilization. Continued pipeline operation is vitally important to Alaska's economy, which depends heavily on the oil industry for jobs and revenue.

Technology development will enable use of unmarketable domestic gas resources.

Current projections for producing Alaskan oil reserves show that, in order to ensure operation of the Trans Alaska Pipeline System, gas-to-liquids technology must be ready for deployment between 2009 and 2016. DOE and industry researchers are working together to ensure that advanced, cost-effective conversion technology will be ready for U.S. commercialization within that time frame.

Economic Barriers to GTL

The investment hurdles of present GTL technology are formidable, and the gas conversion industry is in its infancy. Reducing capital requirements is a key goal of DOE's gas conversion research. Shell Oil's pioneer 125,000 barrels per day GTL plant in Malaysia cost over $600 million to build in the mid-1990s. In the Mideast nation of Qatar, there are proposed plans to build larger GTL plants, from 20,000 to as much as 100,000 barrels per day. These plants could cost from nearly $750 million to as much as $3 billion or more. Building similar-sized plants on Alaska's North Slope could cost 35 to 70 percent more because of harsher weather conditions and greater inaccessibility.

In today's intensely competitive global business environment, many U.S. oil and gas companies have concentrated their investments overseas. Potential GTL technology advancement and economic conversion of remote gas would encourage companies to examine GTL opportunities in the U.S.

DOE is working with industry to remove the technology and economic barriers to producing Alaska's North Slope gas reserves. Breakthrough technologies under development will improve the economics of large-scale GTL technology, making it economically viable and competitive with other projects around the world. Improvements in the economics of small-scale GTL technology are also important for capturing small, remote gas deposits, such as those in the Gulf of Mexico, which are distant from economical pipeline access.

Industry Issues

- *Dwindling Alaska North Slope oil volumes rendering continuous operation of the Trans Alaska Pipeline System infeasible, halting full recovery of North Slope oil.*
- *More stringent clean air environmental standards, demanding new petroleum refinery investments and adding operating costs to improve the clean-burning quality of traditional liquid transportation fuels.*
- *Incremental cost additions to reduce impurity levels of known, unproduced, low-quality natural gas resources.*

Expanding Production of Low Quality Gas

Improving the economics of gas upgrading technologies is another priority for joint DOE-industry efforts. More cost-effective gas purification technologies would allow greater volumes of low quality gas to be marketed.

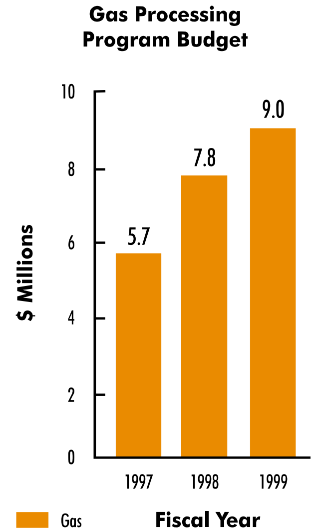
Approximately one-third of our Nation's natural gas resource is low quality gas that does not meet market specifications for pipeline shipment. Typical specifications call for gas with no more than: 2 percent carbon dioxide; 4 percent total carbon dioxide, nitrogen, and other inert gases; and 4 parts per million of hydrogen sulfide gas.

Some low quality gas can be blended with higher quality gas to meet market requirements. But much of our low quality gas must be upgraded through gas purification technologies that eliminate or substantially reduce inert and hazardous contaminants. Current technologies can be costly and, in some cases, cost-prohibitive. In situations where the cost of upgrading would make producing the gas uneconomical, the gas is simply shut-in. Advanced upgrading technologies under development will improve purification techniques, while significantly lowering costs.

Utilizing Coal Mine Methane

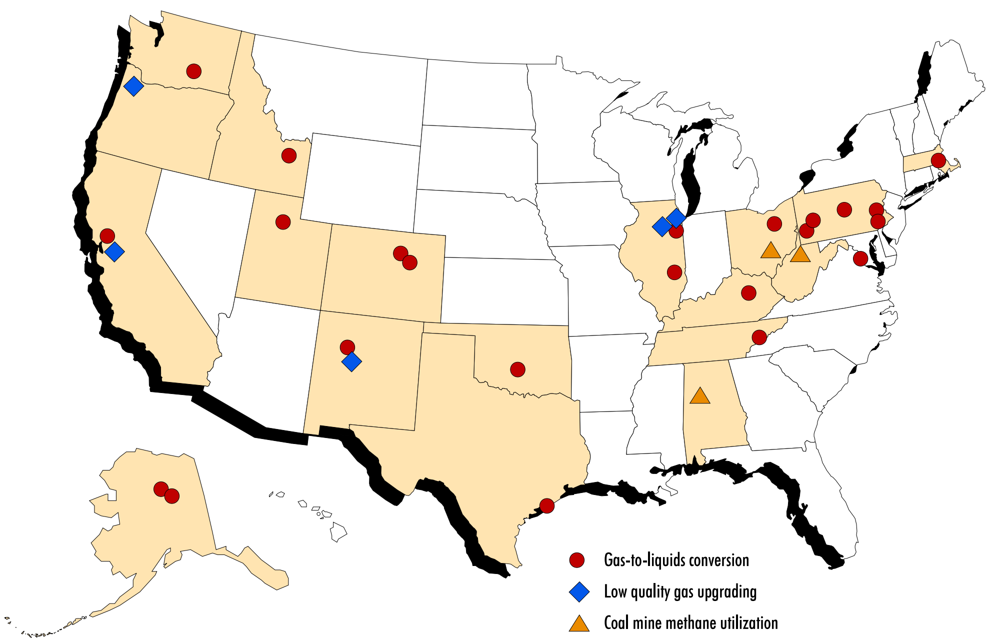
Methane is released naturally from coal and surrounding strata in the course of underground coal mining. Most of this methane, a greenhouse gas, is currently exhausted to the atmosphere through the mine ventilation system.

Coal mine methane RD&D efforts focus on the demonstration of available methods to economically collect and utilize this methane for pipeline sales, small-scale electric power generation, and other uses. The goal is to expand the number of mines that utilize emitted gas, instead of releasing it into the atmosphere.



Project Sites

Project activities are underway in over 20 locations across the United States.



GAS PROCESSING

Drivers

- Our Nation's most accessible and economical supplies of oil and gas are being depleted.
- Utilization of remote, low quality natural gas resources could contribute to maintaining a reliable domestic supply of environmentally superior oil and gas fuels.
- Current economics limit the use of technologies for gas conversion to easily transportable, clean-burning, high-performance liquid fuels, and for upgrading low quality gas.
- Timely advances in GTL technology development and demonstration are critical to extend production of ANS oil and to maximize oil and gas production in the Gulf of Mexico and western U.S. basins.
- Increasingly stringent environmental laws and regulations are intensifying the need for advanced technologies that can provide cost-competitive, clean-burning liquid transportation fuels.

Goals

- Develop gas-to-liquids conversion technologies that offer significant cost reductions when compared to today's marginally cost-effective processes, and transfer these technologies to industry in the 2005 to 2010 time frame.
- By 2002, identify new, high-performance, clean-burning motor vehicle fuels for post-2004 vehicles, based on presently unmarketable natural gas (and other unused fossil fuel resources).
- Develop and transfer to industry cost-effective technologies for upgrading low quality natural gas to pipeline quality for direct use, and for converting gas to higher hydrocarbon liquid fuels.
- By 2010, monitor private sector deployment of advanced GTL technology and continue exploration of further advances in GTL technology and product delineation for advanced transportation systems.
- Demonstrate technologies to cost-effectively capture and productively use methane gas, which is released during underground coal mining.

Gas Processing Program

Strategies

- Delineate optimum, advanced motor fuel GTL product(s)/ feedstock(s) that meet national environmental and efficient fuel use goals.
- Demonstrate, at pilot plant level, the first phase of GTL manufacture of syngas using air-separating ceramic membrane reactors.
- Complete demonstration of an integrated GTL chemical conversion process offering 25 percent cost reductions over current technology.
- Develop and expand high-productivity syngas-to-fuel conversion reactor technology to establish a sound foundation for a competitive GTL industry.
- Provide a comprehensive database for syngas and GTL fuel manufacture utilizing advanced methane partial oxidation technology, and state-of-the-art catalyst and high productivity reactor systems.
- Foster annual retrofit of 5 to 10 percent of existing acid gas treatment facilities, upgrading low quality, high carbon dioxide and hydrogen sulfide natural gas with advanced processes offering 50 percent cost reductions.
- Develop cost-effective organic and inorganic membranes for separating low quality gas components.

Measures of Success

By 2010, DOE and industry partnerships will yield:

- Advanced techniques for nitrogen and hydrogen sulfide/carbon dioxide removal from low quality gas will expand domestic production potential by more than 150 Bcf per year.
- Production of 200,000 barrels per day of high quality GTL liquid transportation fuel will be made from Alaska's North Slope gas resources.
- Advanced GTL conversion technology, yielding ultra-clean burning diesel fuels that meet the most stringent emissions requirements, at costs equal to or below those of comparable fuels made from crude oils.
- Small-scale GTL technology that will enable production of remote offshore oil reservoirs with associated gas, and onshore gas reservoirs without pipeline access.
- Utilization of an additional 13 Bcf per year of coal mine methane gas through innovative gas recovery, upgrading, and electric power generation.

GTL-based diesel fuel offers significant reductions in emission levels.

Relationship to Other DOE Programs

The Gas Processing Program has links to a number of areas in the overall DOE oil and gas technology effort, including natural gas production, storage, and environmental areas primarily through the program's gas upgrading effort. Even stronger are the GTL program links with the coal transportation fuel component of Fossil Energy's Coal and Power Systems Program, which focuses on selected conversion technologies common to GTL and indirect coal liquefaction.

Both efforts maintain strong cooperation with Energy Efficiency and Renewable Energy's (EE) Transportation Technology and Hydrogen programs. Links are also maintained with the Department's global climate change action effort, as appropriate. The technology transfer mechanisms built into all DOE programs ensure that information and RD&D results are shared among interrelated programs to achieve maximum benefits.

Program Areas

The Gas Processing Program consists of three areas:

- Gas-to-liquids conversion;
- Low quality gas upgrading; and
- Coal mine methane collection and utilization.

The following pages highlight some specific Gas Processing Program projects and their results.

Gas-to-Liquids Conversion

Gas-to-liquids conversion technologies use chemical or physical means to convert natural gas to a liquid form suitable for ready transport or direct use. The conversion is accomplished in one of two ways:

- Compression and refrigeration, in which the gas is liquefied cryogenically and subsequently re-gasified for eventual use; or
- Chemical conversion, in which the gas molecules are chemically altered and combined to form a stable liquid that can be used directly as a transportation fuel or petrochemical feedstock / product.

Program efforts to advance gas-to-liquids conversion technologies are focused on new approaches and processes to significantly reduce costs and accelerate deployment.

Economics of Alaska's North Slope Gas Options

A program strategy / assessment project was conducted by DOE's Idaho National Engineering and Environmental Laboratory in August 1996, with technical assistance from oil industry consultants and DOE personnel. The project examined the economics of Alaska's North Slope gas options. The study objective was to determine whether application of gas-to-liquids technology could make economical an estimated 25 Tcf of known, producible North Slope gas.

The study found that current state-of-the-art GTL technology would be economically comparable to the large-scale liquefied natural gas manufacture and export plan also proposed for the ANS gas.

This conclusion incorporates the savings to current oil producing reservoirs that would result from extending the productive life of Trans Alaska Pipeline System, but conservatively ignores the benefits for new oil reservoirs. The study also found that near- and mid-term advancements in GTL technology would lower the cost of this option by 25 percent or more, primarily through reduced capital costs and conversion efficiency gains.

Ultra-Clean Liquid Transportation Fuels from Conversion of Natural Gas

This engineering development project builds upon the success of exploratory process research that showed oxygen ions could pass through selected ceramic membranes. This opens up the potential for air separation and partial oxidation of methane in a single-step ceramic reactor to make the key intermediate product "syngas," which can be readily converted to clean liquid fuels and other hydrocarbons. Syngas is composed of hydrogen and carbon monoxide, and is converted in a separate Fischer-Tropsch reactor to desirable, long-chain, paraffinic hydrocarbons. Early work suggests that costs of such chemical conversion of gas could be reduced by as much as 25 percent with ceramic membrane technology, depending upon conversion plant configuration.

Success Story

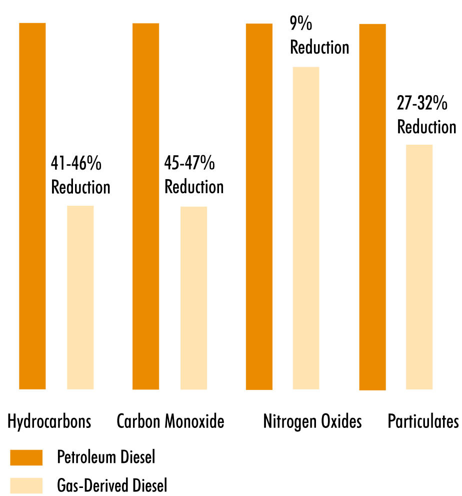
Economic Utilization Options for Alaska North Slope Gas

The Alaska GTL and LNG assessment by INEEL provided State and industry leaders with credible scientific and technical information, useful in considering the options and timing for future gas production decisionmaking. The study also triggered active examination of GTL applicability in Alaska by several companies with major ANS gas holdings. Updates of the study are anticipated as needed.

The prospects of this and other conversion process improvements enhance practical options for significant use of GTL fuel products (or blendstock) as a way to reduce air pollution and greenhouse gas motor vehicle emissions through better engine performance, without raising prevailing fuel costs.

The exhibit below shows the proportional reduction in emission components using syngas-derived diesel fuel, (from gas and coal feedstock) compared to two other modern oil-based diesel fuels, which were tested using a 1991 heavy-duty truck diesel engine. Note that different engines will have differing results, but subsequent tests show similar emission improvement.

Emissions Reduction Relative to Low-Sulfur Petroleum Diesel



Note: Non-Optimized Engine Tests, Southwest Research Institute.

Less dramatic but still significant emission improvements have been noted in newer, better performing engines using cleaner conventional fuels, indicating the importance of GTL fuels as a vital fuel option.

Work began on the Ionic Transport Membrane Syngas project in 1998. A 12-member industry, university, and National Laboratory team headed by the industrial gas company, Air Products and Chemicals, was selected through a competitive solicitation to develop this advanced process approach to pre-commercial scale over a 7 to 8 year time frame. Phase I work, to be completed by early 2000, includes: determination of ceramic membrane composition; and design of a high-temperature reactor and metal-ceramic seals to enable continuous process testing at laboratory scale. Sequential scale-ups and testing of the breakthrough syngas generation technology will follow in subsequent phases. These will include test integration with a syngas conversion reactor at DOE's Alternative Fuels Development Unit in LaPorte, Texas.

This Fossil Energy project is also supported by DOE/EE's Hydrogen Program. In addition to major cost-share funding (2/3 industry and 1/3 DOE), the project features a repayment agreement by which DOE funds will be repaid upon process commercialization.

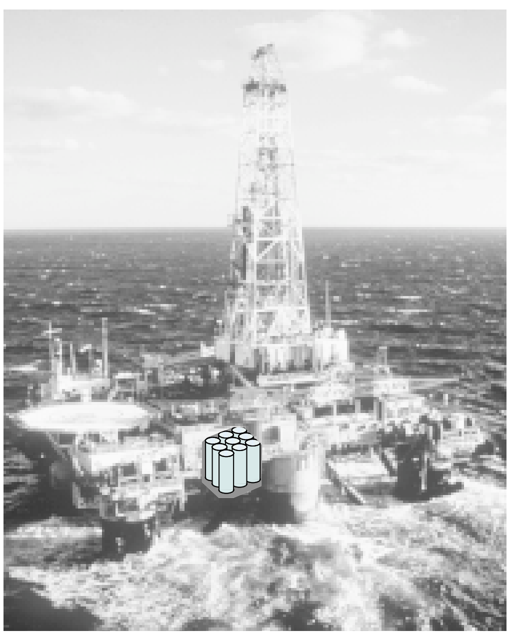
In addition to this effort, the GTL program is also supporting separate university studies of the use of ceramic membranes for syngas generation in a different process approach.

Thermoacoustic Natural Gas Liquefaction

Another government-industry collaboration involves Los Alamos National Laboratory and Cryenco Inc., a small Colorado manufacturing subsidiary of Chart Industries, specializing in cryogenic storage technology. Together, they are developing a process for small-scale liquefied natural gas manufacture at remote offshore and onshore locations. This project builds directly on exploratory work sponsored by DOE's Science and Defense programs.

The process uses direct gas burning to generate sound waves to drive a refrigerator. This process is designed for small-scale LNG generation at wellhead or other locations, at one-half the cost of traditional refrigeration at similar scale. The process has no moving parts, does not require electricity, and lends itself for use at remote offshore locations.

This LNG process innovation has been taken from basic theoretical refrigeration concepts to a working experimental unit capable of liquefying gas at a rate of up to 140 gallons per day at 60 percent efficiency. With continuing design and analysis support from Los Alamos National Laboratory scientists, a cost-shared "Thermoacoustic Sterling Hybrid Engine Refrigerator" (TASHER) prototype is being built by Cryenco. Target capacity is 10 barrels per day, with an efficiency of 70 percent. Following successful field testing, scale-ups by industry to levels of 250 to 1,000 barrels per day of LNG capacity (1 to 4 MMcf per day) at target efficiencies of 80 percent or better are anticipated.



Conceptual view of small scale Thermoacoustic LNG technology application on an offshore rig.

Governments throughout the world have become increasingly alarmed at wasteful flaring of natural gas coproduced in small to moderate volumes with various oil fields located far from gas-to-market pipelines. The thermoacoustic LNG device, TASHER, now under development with DOE assistance for small-scale LNG manufacture on offshore platforms, could enable safe and economical utilization of currently flared gas. TASHER would also eliminate the need for large power generation and gas compressing equipment and allow transportation of LNG with barges or ships to onshore markets.

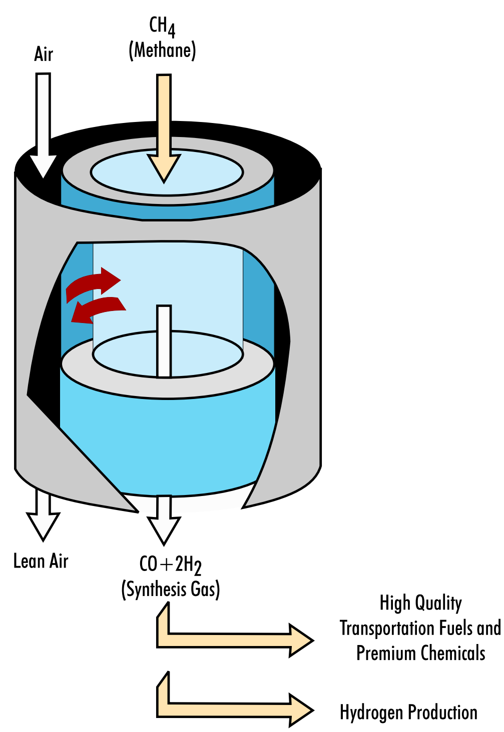
Steady-State & Transient Catalytic Oxidation and Coupling of Methane

Direct chemical conversion of methane to a desirable liquid hydrocarbon has long been a DOE research goal. However, conversion of the methane molecule to different, highly selective compositions has proven difficult in the quantities and yields required to approach economic feasibility. DOE-sponsored research at the University of California at Berkeley, focuses on oxidative coupling, a method by which oxygen reacts over a catalyst with methane to form water and a methyl radical. The methyl radicals combine to form a higher alkane, such as ethane, which then dehydrogenates easily to an olefin, such as ethylene.

One of the challenges of this process is the rapid formation of carbon dioxide before the radicals link up, due to reaction thermodynamics. Berkeley researchers are exploring whether quick separation of the oxygen and radical streams as the reactions take place can achieve the objective of significantly increasing single-pass yields of alkanes above the 25 percent levels achievable with today's best coupling technology. To accomplish this separation, the use of a surface-catalyzed proton membrane is being tested.

CERAMIC MEMBRANE TECHNOLOGY

The partial pressure difference in oxygen, which occurs between the air side and the methane side of the membrane when synthesis gas is formed, facilitates oxygen ion transport through the membrane.



GAS PROCESSING

Low Quality Gas Upgrading

Efforts to advance gas purification technologies are focused on finding lower cost ways to remove sulfur, carbon dioxide, nitrogen, and other impurities from low quality gas. Gas purification technologies enable the upgraded gas to meet specifications for pipeline shipment to market.

The low quality gas upgrading program targets two technology areas. The first is the development of organic and inorganic membranes that screen and separate gas components. Membranes offer high component selectivity and overall gas throughput. The second area of technology development is gas-contaminant absorption and adsorption systems that have rapid regeneration capability.

Both areas of technology development have the potential to significantly reduce gas upgrading costs, compared to current technologies.

Microbially-Enhanced Reoxidation for Sweetening Sour Natural Gas

Researchers at Texas A&M University at Kingsville are looking at new ways to improve current technology for removal of hydrogen sulfide from gas. When found in moderate concentrations, hydrogen sulfide is often removed from gas through the absorption of the sulfide in an absorbent. This is followed by regeneration of the absorbent by partial oxidation of the sulfide to elemental sulfur and water. However, reoxidation of the absorbent can be slow and irregular.

With support from DOE and GRI, Texas A&M researchers are examining how families of microbes can enhance the reoxidation rates, and what process conditions best facilitate reoxidation. Enhanced reoxidation rates would enable purification plants to operate continuously, which, in turn, would allow a reduction in plant size. Smaller purification plants would require less capital and operating costs.

Methane Separation from Nitrogen by Methane-Permeable Membranes

The removal of nitrogen from natural gas is an expensive operation, and these processing costs can jeopardize potential development of fields containing high nitrogen concentrations. Researchers at Membrane Technology & Research, in Menlo Park, California, are looking at new semi-permeable membranes that can selectively pass the slightly smaller methane molecules in natural gas and resist the larger nitrogen molecules.

Based on positive findings for two of the membranes examined, researchers are focusing on the development of spiral-wound membrane modules for laboratory and subsequent pilot process testing.

Initial modules are now undergoing field testing in an active Midwest gas field. Semi-permeable membranes could potentially lower nitrogen removal costs by as much as 50 percent, compared with current cryogenic processes.

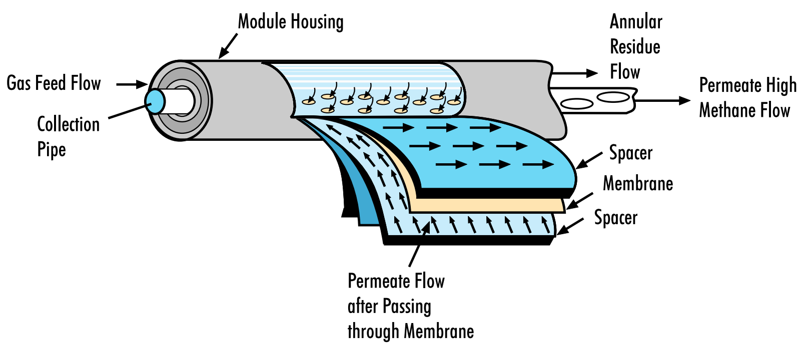
High Efficiency Gas-Liquid Packing and Contactors for Acid Gas Processing

Another DOE-sponsored project is focused on developing more efficient and compact physical solvent systems for upgrading natural gas with high carbon dioxide and / or hydrogen sulfide content. Researchers at the Institute of Gas Technology are working with representatives from GRI, Shell Oil, Krupp Uhde, and others to develop and demonstrate the advanced system designs.

Advances are required to enable the separation processes to proceed, using structured packing and / or rotating solvent-gas contactors in place of traditional, large absorber towers with many sets of contactor trays.

The new designs would allow a five-fold reduction in the size of gas upgrading plants. Such size reduction is particularly valuable for platform scale upgrading in the Gulf of Mexico.

Typical Spiral-Wound Gas Separation Membrane Module



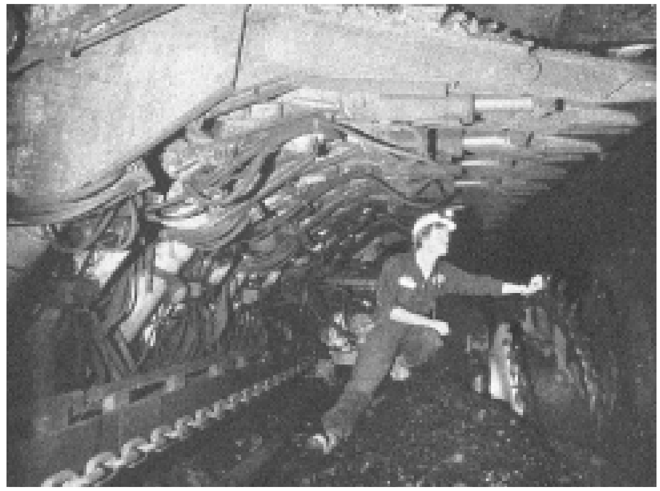
In this model case, smaller methane molecules would pass from the raw feed flow through a selectively permeable membrane to a lower pressure collection pipe. Larger nitrogen molecules would not pass through the membrane, remaining as residue in what would become a high nitrogen waste stream.

GAS PROCESSING

Coal Mine Methane Collection and Utilization

Following a demonstration design competition, two of five mines located in Alabama, Ohio, Pennsylvania, and West Virginia, will demonstrate the feasibility of alternate ways to recover and utilize methane released during the underground coal mining process. Subject to final selection, the projects will demonstrate the productive use of low methane ventilation gas, and/or longwall mine gob gas of irregular methane content for pipeline sales, small-scale electric power generation, and/or other uses.

Design activities for each of the five cost-shared design projects are to be completed in 1999. These demonstration proposals reflect either new concepts for mine methane use or build on earlier utilization successes. For example, at an active coal mine in Harrison County, Ohio, DOE and industry partners have developed an electric power generating facility fueled by waste methane. The facility is currently generating 500 kW of electricity, about one-quarter of the mine's total power consumption. The new demonstration project will expand the power generating facility with the addition of a fuel cell.



"Longwall" Underground Coal Mining

Success Story

Acid Gas Removal

An extensive test series of upgrading low quality gases with both large and small concentrations of acid gas, using new morphline derivatives as physical solvents, has been successfully completed. This marks the introduction of the "Morphysorb" upgrading process by Krupp Uhde and IGT. Natural gas and syngas upgrading processing with the new solvent process shows cost reductions of 30 to 50 percent for impurity concentrations as high as 70 percent carbon dioxide and 3 percent hydrogen sulfide. This new upgrading process is accomplished with less hydrocarbon loss and lower cost equipment than previous processes.